



**HCU FLIGHT S/W
BUILD 2
PRODUCT PLAN**

SSPP-REF-203

REVISION B

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**Goddard Space Flight
Center**
Greenbelt, Maryland

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1.0 Introduction

This document describes the plan for development of the Hitchhiker Central Unit (HCU) flight S/W Build 2.

1.1 Purpose

The purpose of the HCU flight S/W Build 2 effort is primarily to add three new features to the HCU Build 1 capability:

Group commands – This is the ability to load customer command sequences prior to the launch of a given Hitchhiker mission. These command sequences can then be executed during the mission via the issuance of a single ground command.

Time delayed commands – This is the ability to upload customer and HCU command sequences during the mission for automatic execution at a designated time in the future.

Umbilical interface – This is the ability to upload new flight software and group commands to the HCU via cabling to Ground Support Equipment (GSE).

As a secondary goal, the Build 2 effort will attempt to identify, isolate, and correct software problems encountered during testing of the Build 1 baseline system.

1.2 Background

The (HCU) is a component of the next generation Hitchhiker avionics system known as the Advanced Carrier Equipment (ACE). It is the central processor of the system, which, along with the Hitchhiker Remote Interface Unit (HRIU) gathers telemetry from and distributes commands to customer experiments. In addition, it provides telemetry for Hitchhiker health and safety status and executes commands for controlling power to the customer experiments.

1.3 Product Plan Review and Update

This document shall be reviewed by members of the Shuttle Small Payloads Projects (SSPP) Office, Code 870, and the HCU Flight S/W Development Team. It will also be reviewed and approved by the Real-Time Software Engineering Branch, Code 584, management.

This document has been developed and will be maintained by the HCU Build 2 development team. It may be updated to reflect changes in project requirements.

2.0 Customer Agreement

This section describes the agreement between the SSPP Office, herein referred to simply as ‘the Customer’, and the HCU Flight S/W Development Team including those issues related to requirements, deliverables, and maintenance.

2.1 Customer Identification

Shuttle Small Payloads Projects (SSPP) Office, Code 870.

2.2 Customer Goals and Objectives

The Customer’s goal is to ultimately replace the existing Hitchhiker avionics with the Advanced Carrier Equipment (ACE) of which the HCU is a component. The ACE will provide the Customer a substantial increase in performance and functionality over the existing avionics.

2.3 Requirements

The HCU Flight S/W Build 2 effort will conform to the requirements given in the following documents:

Requirements for Hitchhiker/GAS Bus Communications, HH-SPEC-003, Revision N,
April 16, 1999

Requirements for Hitchhiker Carrier to Ground System Communications, HH-SPEC-004,
Revision H, April 16, 1999

Communication Requirements for the Umbilical UART Programmer to Hitchhiker
Central Unit, HH-SPEC-005, Revision E, April 16, 1999

Data Uploading Requirements for the SSPPO ACE Development, SSPPO memorandum,
March 25, 1999

The requirement for time delayed commands is given in HH-SPEC-004 under the section titled “Delayed Command Time Tag Message Type 23”. The requirement for group commands is given in HH-SPEC-004 under the section titled “Execute Command Group Message Type 27.”

The above requirements documents are controlled by the SSPPO Configuration Management (CM) office.

2.4 Deliverables

- HCU Build 2 flight S/W integrated into the Build 1 baseline
- HCU flight S/W build instructions
- HCU Build 2 design documentation
- HCU Build 2 unit test procedures
- HCU Build 2 test plan
- HCU Build 2 test report
- Other HCU flight S/W system description as necessary

2.5 Necessary Customer Training

The Customer or his designee will be trained in all new system functionality. The Customer or his designee will also be trained in the build procedure. Training will take place in the HCU development lab.

2.6 Medium for Product Delivery

The HCU development lab consists of several computers each dedicated to performing a specific function in the overall development/test environment. All HCU deliverables will be stored on the hard disk of the appropriate computer in the HCU development lab.

2.7 Product Destination

The HCU flight S/W will be loaded into the non-volatile PROMs and EEPROMs of each HCU processor board. Once loaded, the HCU will be available for integration into the Hitchhiker shuttle mounting bridge.

2.8 Post Delivery Maintenance

Maintenance of the HCU flight software will be the responsibility of the Build 2 development team. They will perform modifications to the HCU flight software as needed to address bug fixes and enhancements.

2.9 Customer Supplied Elements

The Customer will supply the Product Design Lead (PDL) and a development team member. Mr. Ben Lui has been identified as the person who will fulfill these roles.

The Customer will provide the Build 1 flight software baseline.

The Customer or its designee will provide the test equipment necessary for the integration, test, and verification of the HCU flight S/W *except* for computer based equipment which contains test software under the cognizance of the development team (e.g., UIU, CIU, MRDU, various simulators).

Other test equipment necessary for operation of the HCU will be provided as well. This includes voltmeters, power supplies, and static free workstations.

2.10 Customer Involvement

Throughout the development of the HCU flight S/W Build 2, the Customer will continue to serve as a point of contact for questions regarding detailed requirements and operation concepts. The Customer will review and approve all significant changes to the source code resulting in an impact to schedule or cost. The Customer will be invited to participate in regular status meetings.

The customer or its designee is also responsible for maintenance and calibration of the test equipment described in 2.9 above.

2.11 Customer Communications

The HCU development team will meet weekly with the Customer to apprise them of project status and discuss issues that need clarification or guidance for the development team to proceed. The development team and the Customer may also meet on an as needed basis for discussion and resolution of certain issues affecting the development effort.

2.12 Authority for Changes

The Customer has approval authority for all changes to requirements and design concepts.

2.13 Acceptance Criteria

The product will be determined to be complete when it is accepted by the Customer. The Customer or its designee will develop an acceptance test plan based on the agreed upon requirements, and execute that plan with participation from the development team. The flight S/W development team may be asked to assist with the development of the acceptance test plan. The Customer will determine which, if any, of the discrepancies noted during acceptance testing must be rectified before acceptance.

2.14 Customer Agreement Review and Update Process

Changes to the customer agreement may be initiated by either the Customer or the development team. Changes will be reviewed and approved by the Customer and the PDL.

3.0 Management Approach

3.1 General Development Approach

The general development approach of the HCU flight S/W Build 2 is dictated by the existing Build 1 design. That is, the HCU is a full custom embedded flight software design driven by a combination of interrupt triggered and polled processes. The software development tools are hosted on a PC, and the code is downloaded to the target hardware and debugged under the control of an in-circuit emulator (ICE). The code is written primarily in Intel assembly language with some C language routines.

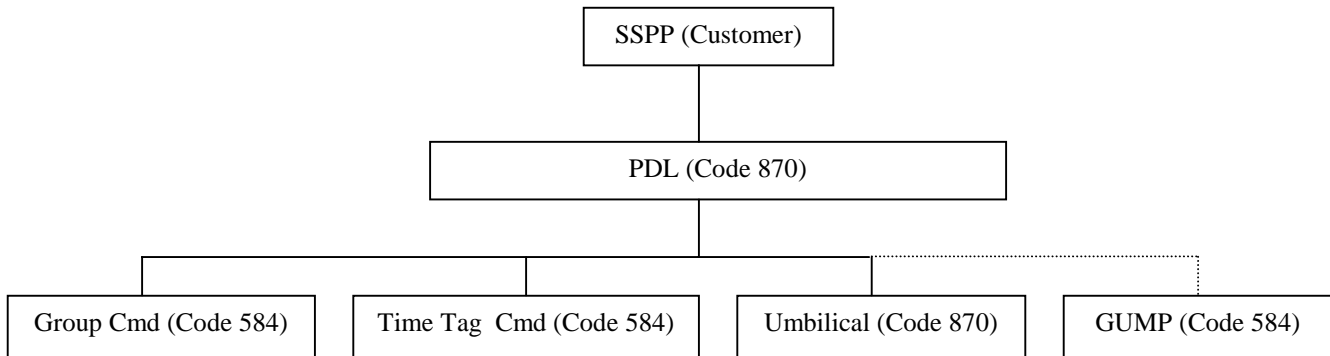
3.2 Resources Needed

The development of the HCU flight S/W Build 2 requires two development team members from code 584 at approximately a 60% level of effort for 12 months. The Customer will provide a team lead/development team member at approximately a 20% level of effort for 12 months.

3.3 Team Organization

3.3.1 Team Organization Chart

The following chart depicts the organization of the HCU flight S/W Build 2 development team. The Ground Umbilical Programmer (GUMP) effort is a companion development with the HCU umbilical interface function.



3.3.2 Team Charter

The HCU flight S/W Build 2 development team will provide all necessary software support to produce a fully functional and reliable HCU.

3.3.3 Team Scope

Although the primary focus of the development team is on Build 2 functionality, the scope of the development team's effort extends to all software-related activities necessary to produce a fully functional and reliable HCU. This includes:

- Development of Build 2 functionality
- Identification, isolation, and correction of agreed upon Build 1 problems
- Integration of new functionality and fixes into the Build 1 baseline

- Build 2 testing
- Regression testing
- Support of acceptance testing
- Support I&T with experimenter or engineering test payloads
- Support mission operations with experimenter or engineering test payloads

3.3.4 Roles, Responsibilities, Authority, Accountability

The development team is responsible for the activities listed in 3.3.3 above. The PDL is responsible for the overall development approach and management of the product development effort. The development team is accountable to the Customer for successful performance of their responsibilities. The Customer maintains approval authority for all decisions affecting functionality, operability, and reliability of the HCU.

3.3.4.1 Development Team

Ben Lui, Code 870, will be responsible for development of the umbilical programmer function. In addition, as the PDL, he assigns specific functional areas for development to the rest of the development team members.

Ron Miller, Code 584, will be responsible for development of the group command function and fixing Build 1 problems.

Pat Hennessy, Code 584, will be responsible for development of the time tag function and fixing Build 1 problems.

3.3.5 Decision Making and Conflict Resolution Process

Decisions related to the HCU flight S/W Build 2 will be made collaboratively by the development team and the Customer. The Customer will have final authority in the event of a conflict.

3.3.6 External Support

Some support will be required of the Build 1 contractor. It is anticipated that this support will be at a 10 – 20 percent level of effort for approximately 3 months.

3.4 Team Interfaces

The HCU flight S/W Build 2 development team will interface with the ACCESS ground system development team for coordinating the details of the command and telemetry interface.

The HCU flight S/W Build 2 development team will interface with the HCU hardware engineers for coordinating test schedules, PROM programming, and troubleshooting problems which appear to be hardware related

The HCU flight S/W Build 2 development team will interface with the HCU acceptance test team for assisting with development and execution of the acceptance test plan if needed.

The HCU flight S/W Build 2 development team will interface with Hitchhiker mission managers to apprise them of the capabilities and operational limitations of the HCU.

3.5 Development Facilities

The HCU flight S/W Build 2 will be developed at GSFC in building 5. System builds and debugging will be performed primarily in HCU development lab. Editing and compiling of individual modules will be done in the HCU development lab and in the developers' offices.

3.5.1 Modifications of Existing Facilities and Schedules

No modifications to the facilities will be required for this effort.

3.5.2 Development of New Facilities and Schedules

No new facilities will be required for this effort.

3.5.3 Physical Security

All development facilities are locked during non-business hours.

3.6 Procurement

No procurement is planned for this project.

3.7 Team Training Plan

The HCU flight S/W Build 2 development team will require training in the use of the development and test equipment. It is anticipated that the Build 1 contractor will provide this training in the form of a few brief, hands-on sessions.

3.8 Risk Mitigation

The primary risk factor in the development of the HCU flight S/W Build 2 is the complete unfamiliarity with Intel 80386 assembly language and process initialization code by the development team. To mitigate this risk the customer has agreed to a development schedule with a liberal amount of contingency.

3.9 Schedule

The development schedule can be found at <http://sspp.gsfc.nasa.gov/hh/access/access.htm>.

3.10 List of Controlled Documentation

The following is a list of controlled documents related to the HCU flight S/W, Build 2 development effort:

Documents controlled by the SSPP under Configuration Management Control:

Requirements for Hitchhiker Carrier to Ground System Communications, HH-SPEC-004,
Revision H, April 16, 1999

Requirements for Hitchhiker/GAS Bus Communications, HH-SPEC-003, Revision N,
April 16, 1999

Communication Requirements for the Umbilical UART Programmer to Hitchhiker
Central Unit, HH-SPEC-005, Revision E, April 16, 1999

Data Uploading Requirements for the SSPPO ACE Development, SSPPO memorandum,
March 25, 1999

Documents controlled by the HCU flight S/W Development Team, some available on the SSPP ACCESS
Home Page (<http://sspp.gsfc.nasa.gov/hh/access/access.htm>):

Product Plan

HCU Flight S/W, Build 2 Product Plan, SSPP-REF-203, Revision A, August 9, 1999

3.11 Process for Process and Product Metric Analysis

The process of the HCU flight S/W Build 2 development effort will be analyzed through the weekly status meetings with the PDL/customer.

Metrics will be collected in accordance with the Code 580 Product Development Handbook, <http://isc.gsfc.nasa.gov/iso9k/pdh/pdh.html>. Metrics collection will commence with the approval of this Product Plan.

4.0 Technical Approach

This section describes the technical approach that will be used to develop Build 2 of the HCU Flight S/W. For more information, see the *SSPP Product Development Management Plan*, 870-PG-8700.1.1, Revision A, July 15, 1999 and the *Software Management Plan for the Shuttle Small Payloads Project*, 870-PG-8700.1.2, Revision B, July 19, 1999 at <http://gdms.gsfc.nasa.gov/gdms/>.

4.1 Software Development Plan

4.1.1 Major Activities

This section describes the major activities planned in the development of Build 2. Several phases and products of the effort have been identified. For more information, see the development schedule at <http://sspp.gsfc.nasa.gov/hh/access/access.htm>.

4.1.1.1 Phases

The product will be developed according to the phases described in the *Software Management Plan for the Shuttle Small Payloads Project*, 870-PG-8700.1.2, Revision B, July 19, 1999.

4.1.1.2 Products Associated with Phases

The products associated with each phase are described in the *Software Management Plan for the Shuttle Small Payloads Project*, 870-PG-8700.1.2, Revision B, July 19, 1999.

4.1.2 Development Methodology

4.1.2.1 Methodology

The methodology used for the development of the HCU flight S/W Build 2 will follow the process outlined in the *Software Management Plan for the Shuttle Small Payloads Project*, 870-PG-8700.1.2, Revision B, July 19, 1999. For this effort the structured design methodology will be used. Due to the size of this effort the preliminary and detailed design phases will be combined.

4.1.2.1.1 Statistical Techniques

The use of statistical techniques has been evaluated, and it has been determined that none are needed.

4.1.2.2 Development Environment

Build 2 software will be developed on a personal computer under DOS 6.2 using the C Programming Language and Intel 80386 assembly language. The following development components will be utilized:

- Intel 80386 C Compiler
- Intel 80386 Assembler
- Intel System Binder
- Intel System Builder
- Intel In-Circuit Emulator, Part # ICE-386 DX

4.1.2.3 Utilized Standards

There are no standards utilized in this development

4.1.2.4 Utilized COTS Products and Tools

There are no COTS products or tools used in the HCU flight S/W design.

4.1.2.5 Build Strategy

The HCU Flight S/W, Build 2 will be built and released in one phase.

4.1.2.6 Product Inspection and Test Approach

Inspection and test will be performed in accordance with the *Software Management Plan for the Shuttle Small Payloads Project, 870-PG-8700.1.2, Revision B, July 19, 1999*. A code walk-through, though not specifically required, will be performed.

Calibration records of ancillary equipment needed for the test and development environment are maintained by Code 568.

Test software is tested for proper operation in an iterative fashion along with the testing of the flight software. Discrepancies in either software will cause obvious erroneous indications on the test computer displays. These erroneous indications are then traced back through both the flight code and the test software until the cause is determined.

The test verification and validation plans will be approved by the Hitchhiker Ground Data System lead. The HH GDS lead will also approve changes to these plans.

4.1.2.7 Acceptance Criteria and Objectives

Acceptance criteria and objectives will be established in accordance with the *Software Management Plan for the Shuttle Small Payloads Project, 870-PG-8700.1.2, Revision B, July 19, 1999*. These criteria and objectives will be defined by an independent acceptance test team.

4.1.2.8 Reviews Planned

Per the *Software Management Plan for the Shuttle Small Payloads Project, 870-PG-8700.1.2, Revision B, July 19, 1999* informal reviews with the Customer/PDL will be conducted at each phase of system development.

4.1.3 Incoming Inspection and Test

There are no purchased products planned for this development.

4.1.4 Control of Test Equipment

Control of the test equipment provided by the Customer is the responsibility of the Customer. Control of significant test software products under the cognizance of the development team will be achieved through processes defined in the *Software Management Plan for the Shuttle Small Payloads Project, 870-PG-8700.1.2, Revision B, July 19, 1999*.

4.2 Process for Transportation, Identification, and Medium of Product

The product will be delivered as described in section 2.6 of this plan. A tape archive copy of all source files will be delivered to the CM office for each new release of the HCU flight software. Weekly back-ups of the source files will be stored at an off-site location.

4.3 Technology and Commercialization Plan

There will be no technology and commercialization plan for this product.

4.4 Servicing – Process for Product Maintenance

Product maintenance will be performed in accordance with the *Software Management Plan for the Shuttle Small Payloads Project, 870-PG-8700.1.2, Revision B, July 19, 1999*.

5.0 Product Assurance

5.1 Assumptions and Constraints

It is assumed that the HCU flight S/W Build 1 software upon which Build 2 will be based was developed to “best engineering standards and practices”. The HCU Build 2 development team is resource constrained such that a thorough analysis of the Build 1 design and implementation is not feasible. Although every effort will be made to isolate and correct problems found with the Build 1 baseline, overall product reliability will depend heavily on the integrity of the Build 1 design.

5.2 Quality Assurance

5.2.1 Control of Non-Conforming Products

Control of non-conforming products will be in accordance with the *SSPP Quality Management Plan*, 870-PG-8730.4.1. For minor non-conformances the GSFC Information Systems Center, Code 580, library process will be used (<http://isc.gsfc.nasa.gov/iso9k/atp/ATP12.html>). The minor NCR reporting/tracking system used is the Bugzilla server maintained at <http://itos.gsfc.nasa.gov>.

5.2.2 Corrective and Preventative Action

Corrective and preventive action will be in accordance with the *SSPP Quality Management Plan*, 870-PG-8730.4.1. For minor non-conformances the GSFC Information Systems Center, Code 580, library process will be used (<http://isc.gsfc.nasa.gov/iso9k/atp/ATP13.html>).

5.2.3 Control of Quality Records

Control of quality records will be in accordance with the *SSPP Quality Management Plan*, 870-PG-8730.4.1. The Hitchhiker Ground Data System lead is the quality record coordinator. The Hitchhiker Ground Data System lead maintains a copy of the quality record list.

5.2.4 Control of Documents and Data

Control of documents and data will be in accordance with the *SSPP Quality Management Plan*, 870-PG-8730.4.1.

5.3 Configuration Management

Configuration management will be performed in accordance with the *Software Management Plan for the Shuttle Small Payloads Project*, 870-PG-8700.1.2, Revision B, July 19, 1999. Specifically, the *Hitchhiker Ground Data System Configuration Management Plan*, SSPP-REF-215, February 2, 2000, will be used.

5.3.1 Identification and Traceability of Products

Identification and traceability of a software release will be performed in accordance with the Configuration Change Request (CCR) process described in the *Software Management Plan for the Shuttle Small Payloads Project*, 870-PG-8700.1.2, Revision B, July 19, 1999.

5.3.2 Control of Customer Supplied Elements

The customer will supply the HCU flight S/W Build 1 code as the baseline for developing Build 2. This software is not under configuration control. The code will be copied to a new directory on the development PC for making Build 2 modifications.

6.0 Plan Update History

Version	Date	Description	Affected Pages
1.0	April 7, 1999	Original	All
A	August 9, 1999	Updated	All
B	February 23, 2000	Updated	All